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RACIAL DIFFERENCES IN HERITABILITY ESTIMATES FOR TESTS OF SPATIAL ABILITY.

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THE PRIMARY PURPOSE OF THIS STUDY WAS TO TEST THE HYPOTHESIS OF DIFFERENTIAL HERITABILITY RATIOS FOR WHITE AND NEGRO CHILDREN ON TESTS OF SPATIAL ABILITY. IN A TABLE THE TWO GROUPS ARE COMPARED ON EIGHT SPATIAL ABILITY TESTS BY FOUR DIFFERENT HERITABILITY ESTIMATES. IT IS CLEAR FROM THE TABLE THAT ONLY THE OBJECT APERATURE TEST YIELDS CONSISTENTLY HIGHER HERITABILITY RATIOS FOR WHITE THAN FOR NEGRO CHILDREN. ON THE BASIS OF DATA PRESENTED IN TABLE 1 THE HYPOTHESIS OF THE DIFFERENTIAL RATE OF GENETIC OR BIOLOGICAL CONTRIBUTIONS FOR WHITES AND NEGROES ON SPATIAL TEST PERFORMANCE MUST BE REJECTED. THAT IS, ENVIRONMENT DOES NOT PLAY A MORE SIGNIFICANT ROLE IN THE MENTAL DEVELOPMENT OF SPATIAL ABILITY OF TEHE DISADVANTAGED (NEGRO) THAN OF THE CULTURALLY ADVANTAGED. THIS SPEECH WAS PRESENTED AT THE AMERICAN EDUCATIONAL RESEARCH ASSOCIATION CONVENTION, CHICAGO, ILLINOIS, FEBRUARY, 1968. (AUTHOR)

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Racial Differences in Heritability Estimates for Tests of Spatial Ability

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Last year at the American Educational Research Association meetings and later in 1967 at the National Academy of Sciences Convention, Arthur Jensen faulted social scientists and educators for their failure to deal with the heredity-environment uncertainty in a "forthright, thorough and intellectually vigorous fashion." He raised two important questions: Is the disadvantage of the "culturally disadvantaged" only cultural or is it genetic and biological? To answer these questions with respect to traits important for success in school and on the job a heritability study of Negroes and non-Negroes has been designed. The purpose of the study is to test the hypothesis that the American Negro is handicapped on tests of spatial ability because of his environmental disadvantage. That is, Negroes perform below other groups on tests of mental ability because environment plays a more significant role in the mental development of the disadvantaged than in the culturally advantaged. If the hypothesis is supported heritability estimates on tests of mental ability should be significantly lower for the disadvantaged Negroes than for groups reared under a more favorable environment.

Method

Same-sexed adolescent twins served as volunteer subjects. The sample consisted of 172 pairs of identical (MZ) twins and 112 pairs of fraternal (DZ) twins. There were 121 boys and 163 girls; 43 pairs were Negro and 241 were white. The age range was from 13 to 18.

The zygosity of the twins was established by serological tests performed under the supervision of Mrs. Jane Swanson of the Minneapolis War Memorial Blood Bank. The following factors were tested for: A, B, O, M, N, S, s, P_1, P_2, Rho, rh', rh", Miltenberger, Vermeyst, Lewis, Lutheran, Duffy, Kidd, Sutter, Martin, Kell, Cellano, and occasionally some others. Twins that differed on one or more of these serological types were considered dizygous.

One hundred and twelve pairs of twins were diagnosed as definitely DZ, that is, they differed on at least one independently inherited blood group. Using only the results of serological tests the remaining 172 pairs were diagnosed MZ with the probability of accuracy no less than 95 times in a hundred.

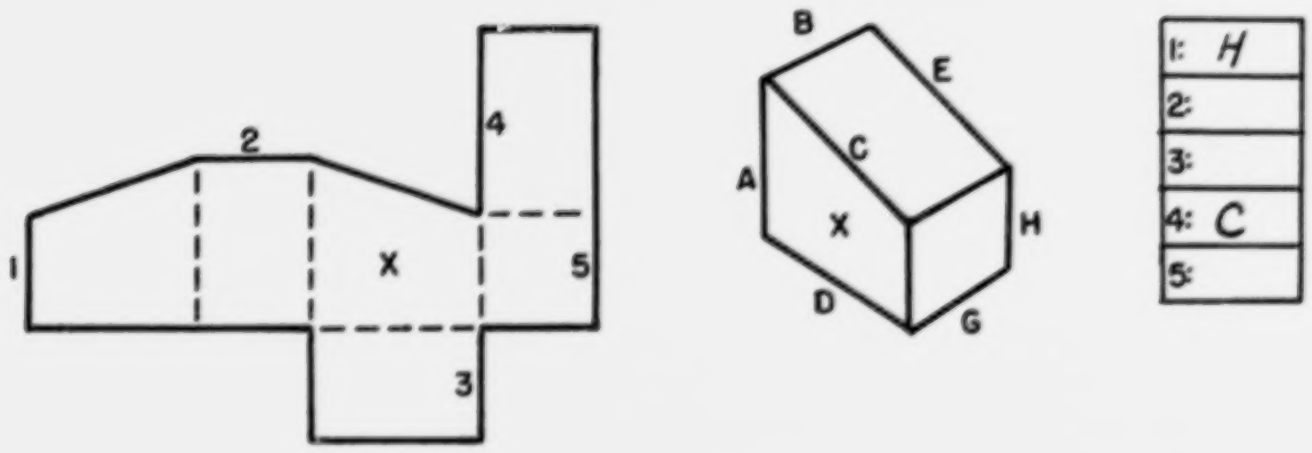
Psychological Tests

Cube Comparisons Test

The Cube Comparisons Test was developed from Thurstone's Cubes. Each item presents two drawings of a cube, such as shown below. Assuming no cube can have two faces alike, the subject has to decide whether the two drawings can represent the same cube or must represent different cubes. The instructions indicate that the task can be performed (1) by mentally turning one of the cubes so that the face of one cube is oriented in the same way as the like face of the second cube and then comparing the sides one by one or (2) by noting whether two faces which are side by side have the same letters or numbers in the same position relative to one another. The process of obtaining the answers by the second method consists largely of verbal reasoning although it does require a "static" awareness of three-dimensional relations as opposed to a more "dynamic" moving around of the blocks in space.

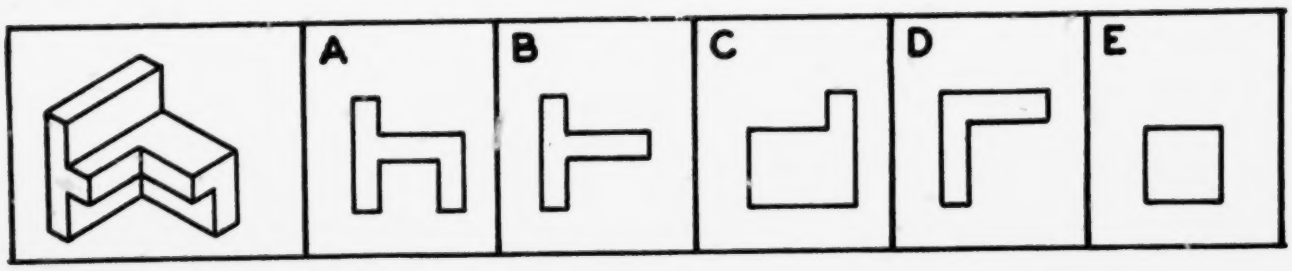
Surface Development Test

The Surface Development Test is adapted from Thurstone. In this test the subject has to imagine or visualize how a piece of paper can be folded to form some kind of object. Each item consists of a drawing of a piece of paper which can be folded on the dotted lines to form the object drawn at the right. (See sample below.) The subject is to imagine the folding, to figure out which of the lettered edges on the object are the same as the numbered edges on the piece of paper at the left, and to identify the letters of the answers in the numbered spaces at the far right. He is told that the side of the flat piece marked with the X will always be the same as the side of the object marked with the X. It appears that this task does require mental movement of the parts of the pattern and it is not likely that the subject can perform this task by verbal reasoning only.



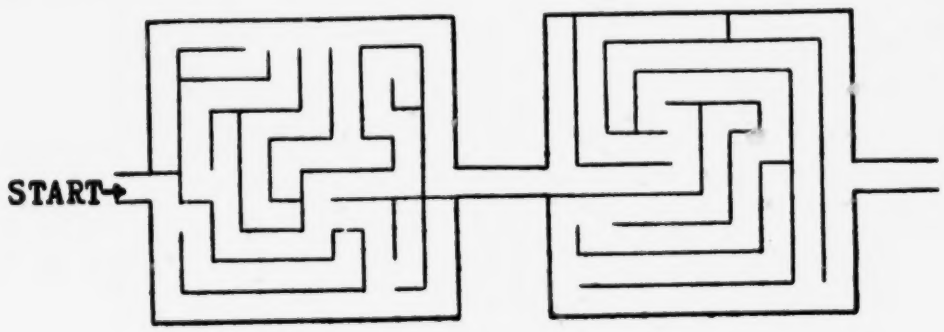
Object Aperture Test

This test of spatial visualization, developed by Philip H. DuBois and Goldine C. Gleser, consists of a number of items similar to the sample below. A three-dimensional object is shown at the left, followed by outlines of five apertures or openings. The subject is to imagine how the object looks from all directions; then to select from the five apertures outlined the opening through which the solid object would pass directly if the proper side were inserted first. This usually requires the subject to mentally turn the object into other positions.



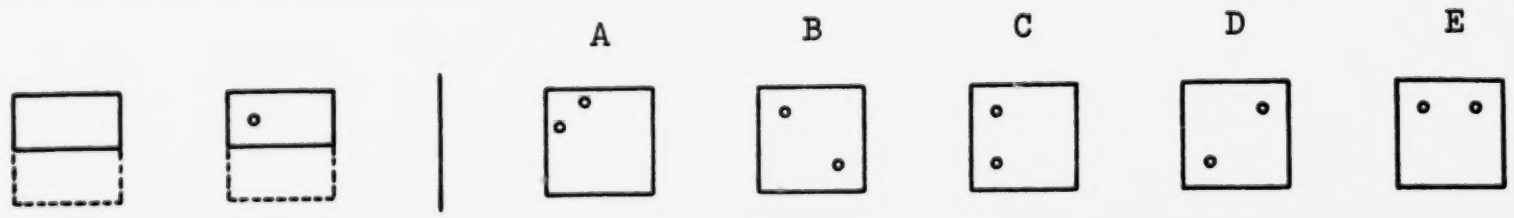
The Mazes Test

The Mazes Test was taken from a laboratory manual by McKinnon and Henle. The task, typical of earlier Maze problems, is to draw a line from one end to the other of the maze without crossing any line or entering blind alleys. Although this test does not require the holding of a 3-dimensional or even of a 2-dimensional figure in mind, it is possible that solution of the task will be facilitated by the ability to remember briefly sections of the correct path before one draws a line. A sample maze is shown below.



Paper Folding Test

The Paper Folding Test was suggested by Thurstone's Punched Holes. For each item, successive drawings illustrate two or three folds made in a square sheet of paper. A drawing of the folded paper shows where a hole is punched in it. The subject selects one of five drawings to show how the sheet would appear completely unfolded. While it is probable that the problems can be solved more quickly if one can easily imagine the folding and unfolding, one can also solve these problems by verbal reasoning. Such verbal reasoning, however, is more likely to lead to incorrect answers. A sample appears below.

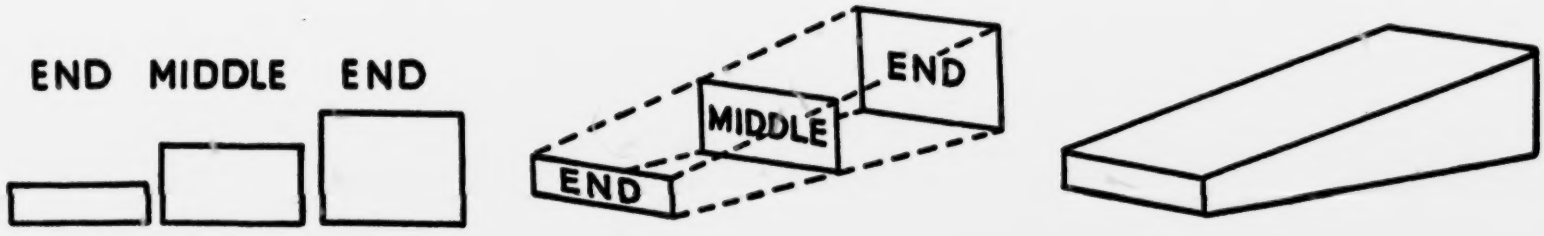


Newcastle Spatial Test

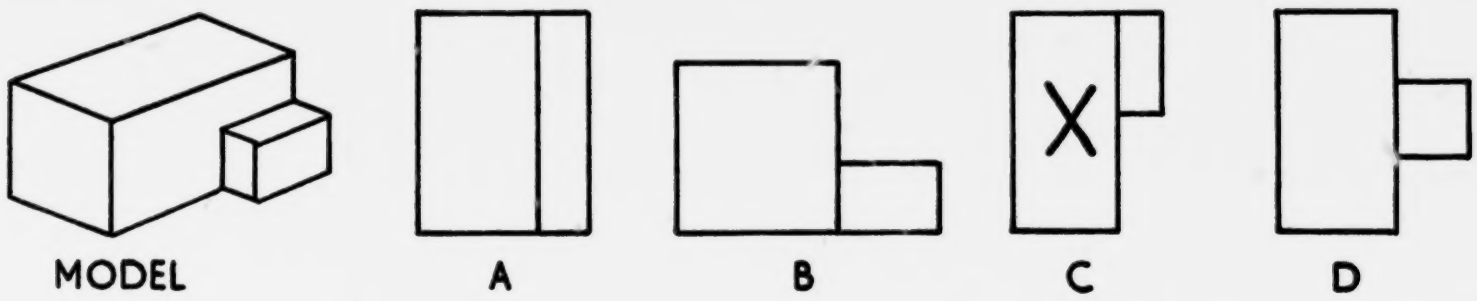
The Newcastle Spatial Test, developed by I. McFarlane Smith and J. S. Lawes for the National Foundation for Educational Research in England and Wales, consists of six different sub-tests ranging in difficulty from simple recognition of selections of regular solids to the more complex problems of surface development.

Test 1 consists of ten sets of drawings in which the end views and middle section of a solid object (in the order end, middle, end) are shown. The subject is to determine which one of 12 solid objects on the opposite page fits each set of drawings. (See sample below.) It appears that this test does not require a very strongly developed spatial ability beyond some idea of perspective drawing.

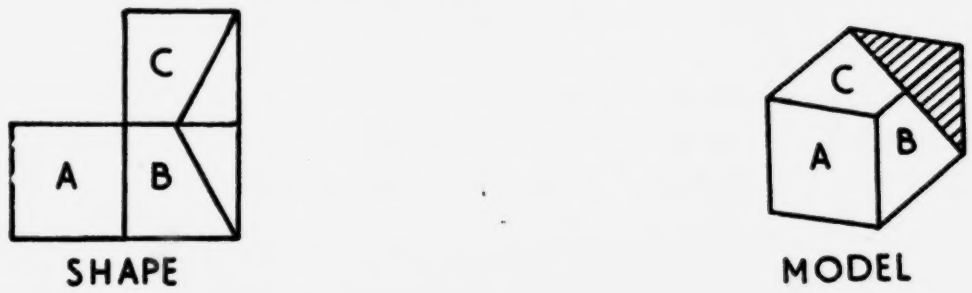
Imagine them placed like this: and you see they form this:



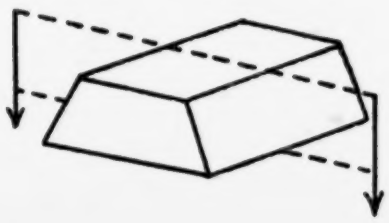
A sample of test 2 is shown below. This test requires the subject to indicate which one of four choices is a view from above of the solid model shown at the left of the row. This test also seems to call for only a modest amount of spatial visualization.

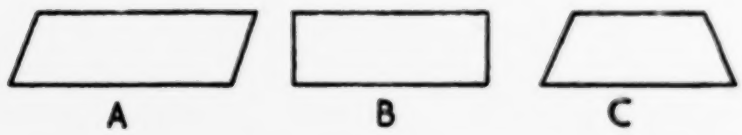


Test 3 consists of items similar to the sample below. In each item the subject is given three sides of a cube in a flat pattern and a drawing of a solid cube, part of which is shaded. The subject is to draw lines on the pattern to indicate where he would cut to remove the parts shown shaded on the solid model. One would probably use spatial visualization to solve this problem although it seems possible to perform the task by verbal reasoning.



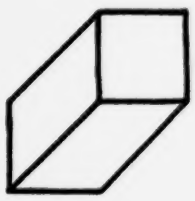
In test 4 each item shows a block of wood. The subject is to imagine a cut made where shown by the dotted lines and to indicate which of the three drawings on the right shows the shape of the cut face. A sample is shown below. It appears that for this task no highly developed ability to visualize 3-dimensional objects is needed.





In each item on test 5 there is a drawing of a solid object, called Shape, and a place to copy it, called Framework. The subject is to put circles around the crosses in the Framework which could be joined to make the Shape. An example is shown below. It appears that it is not necessary to visualize the shape in three dimensions in order to copy it. In fact, the task may be easier if one regards the shape as a flat pattern and merely counts units of distance.

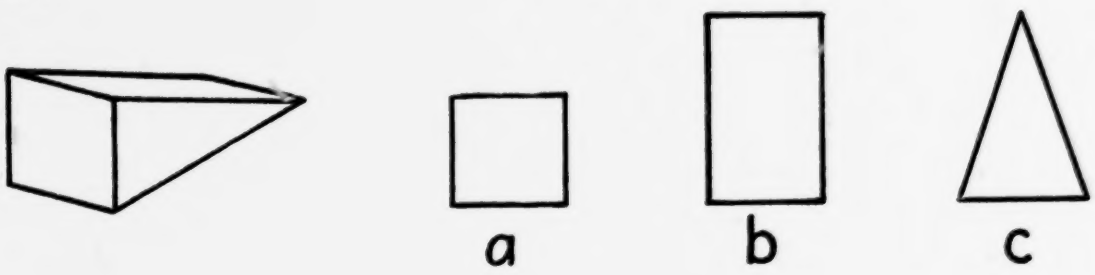
SHAPE **E**



FRAMEWORK **F**

1X 2X 3X 4X 5X
1X 2X 3X 4X 5X
1X 2X 3X 4X 5X
1X 2X 3X 4X 5X
1X 2X 3X 4X 5X

Each item in test 6 (see example below) shows a model built from the shapes shown next to it. The subject is required to indicate the number of times each shape was used to make the model. Although one could rely largely on verbal reasoning to solve these problems, visualization would probably allow him to work much faster.



Identical Pictures Test

The Identical Pictures Test consists of items similar to the one shown below. The subject is to select from the five figures or pictures on the right the one which is identical to the figure at the left of the row. This is a test of perceptual speed.

TABLE 1

Intraclass Correlations and Four Heritability Ratios for Tasks of Visualization, Perceptual Speed, and Spatial Orientation: By Race

TEST	Intraclass r MZ No.	MZ r	DZ No.	DZ r	t corr.	H[a]	HR[b]	F[c]	h^{2d}
Surface Development, 1									
Whites	140	.64	101	.23	3.92	.53	1.27	2.07	.82
Negroes	32	.40	11	-.26	1.73	.52	3.32	1.37	1.32
Surface Development, 2									
Whites	140	.69	101	.37	3.54	.52	.95	1.82	.64
Negroes	32	.59	11	.06	1.54	.56	1.79	1.49	1.06
Surface Development, Tot.									
Whites	140	.75	101	.37	4.42	.60	1.02	2.29	.76
Negroes	32	.62	11	-.26	2.46	.70	2.84	1.83	1.76
Mazes									
Whites	137	.39	95	.08	2.42	.33	1.57	1.44	.62
Negroes	30	.82	10	.18	2.29	.78	1.57	3.10	1.28
Newcastle Spatial Test									
Whites	127	.80	93	.63	2.56	.46	.42	2.20	.34
Negroes	31	.86	11	.59	1.48	.65	.61	.52	.54
Paper Folding									
Whites	138	.49	101	.38	1.05	.18	.46	1.17	.22
Negroes	32	.46	11	-.02	1.27	.46	2.06	.83	.96
Identical Pictures									
Whites	133	.75	96	.49	3.17	.51	.69	1.48	.52
Negroes	28	.61	11	.34	.87	.41	.89	2.56	.54
Object Aperture									
Whites	137	.57	100	.27	2.77	.41	1.06	1.39	.60
Negroes	32	.28	11	.27	.03	.01	.07	.93	.02
Cube Comparisons									
Whites	137	.51	97	.32	1.77	.29	.77	1.61	.38
Negroes	32	.49	11	.01	1.33	.49	1.97	.58	.96

[a] H = Holzinger's heritability ratio (1929), [b] HR = Nichols' heritability ratio (1964), [c] F = Block's F ratio (1965), [d] h^2 = Jensen's formula (1967).

Heritability Ratios

In order to determine the relative intra-pair similarity of MZ and like-sexed DZ twins on selected perceptual tasks four different heritability ratios were computed. (1) Holzinger's (1929) heritability coefficient was computed by the formula:

$$H = (r_{MZ} - r_{DZ}) / (1 - r_{DZ}).$$

(2) The Heritability ratio proposed by Nichols (1965) was computed by the formula:

$$HR = 2 (r_{MZ} - r_{DZ}) / r_{MZ}.$$

(3) The F ratio (Block, 1965) for testing the significance of the difference between the within-set variances of MZ and DZ twins was computed by the formula:

$$F = \sigma_{WDZ}^2 / \sigma_{WMZ}^2.$$

(4) Jensen (1967) offers a new formula defined as the proportion of phenotypic variance attributable to genotypic variance:

$$h^2 = \frac{r_{MZ} - r_{DZ}}{1 - \rho_{\infty}}$$

Results

The significant new findings are summarized in Table 1 which gives the MZ-DZ intraclass correlations for the eight spatial tests and the four different heritability ratios for each variable. All of the MZ correlations were greater than the corresponding rs for the DZ twins.

The remarkable agreement among four heritability ratios invites speculation that the mental abilities represented by the eight spatial tests are independently inherited, with as much as 78% of the within-family variance accounted for by hereditary factors. Heredity and environment produce significantly greater differences in fraternal twins on mental tests of visualization, perceptual speed, and spatial orientation than environmental influences alone produce in identical twins.

Abstract

The primary purpose of this study was to test the hypothesis of differential heritability ratios for white and Negro children on tests of spatial ability. In Table 1 the two groups are compared on eight spatial ability tests by four different heritability estimates. It is clear from the table that only the

Object Aperture Test yields consistently higher heritability ratios for white than for Negro children. On the basis of data presented in Table 1 the hypothesis of the differential rate of genetic or biological contributions for whites and Negroes on spatial test performance must be rejected. That is, environment does not play a more significant role in the mental development of spatial ability of the disadvantaged (Negro) than of the culturally advantaged. /